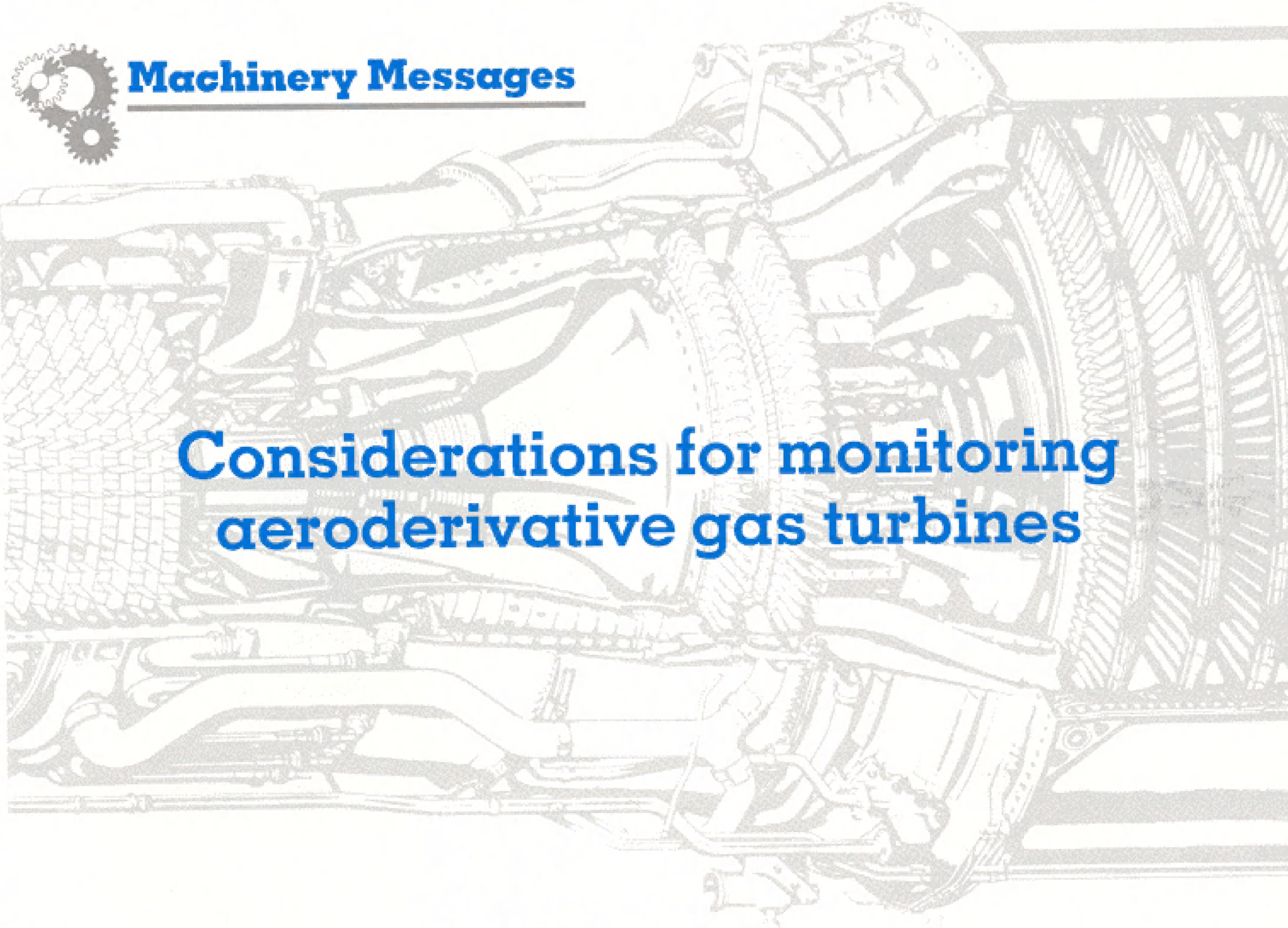
Machinery Messages



Considerations for monitoring aeroderivative gas turbines

BENTLY Nevada aeroderivative gas turbine monitoring systems are currently available using specifications established by the original engine manufacturers. These specifications require seismic vibration transducers which have limitations. Monitoring systems which are based solely on casing or bearing housing seismic measurements cannot provide sufficient information to protect against certain types of engine malfunctions. The following information presents options that can greatly enhance the current seismic-based systems.

Machinery considerations

Most common machine malfunctions, including imbalance and misalignment, originate at the rotor and cause a change in shaft vibration. The extent to which this vibration may be transmitted to the bearing housings and machine casing depends upon the machine's transfer ratio. Using seismic transducers to monitor the effects of shaft vibration requires that the transfer ratio be large and relatively constant with varying machine speed. Experience has shown that transmission of shaft vibration is not constant along the rotor span or machine frame and may vary due to the nature of the vibration source and machine speed.

Seismic measurements, although useful for detecting some machine problems, provide only an indirect indication of shaft vibration. They are not ideal for rotor monitoring purposes and offer limited information for rotor behavior diagnostics.

Rotor vibration occurs typically in the frequency range of 25 Hz (1500 cpm) to 400 Hz (24,000 cpm). Turbine blade passage vibration exists at much higher frequencies, typically 5 kHz (300,000 cpm) to 15 kHz (900,000 cpm). Blade passage vibration routinely causes very high acceleration amplitudes, typically 10 to 100 times higher than the levels from rotor vibration sources.

Measurement considerations

When seismic transducers are specified, the type that has demonstrated the best ability to survive the temperature and vibration environment of aeroderivative gas turbines is the high temperature accelerometer. This trans ducer, however, has its own set limitations.

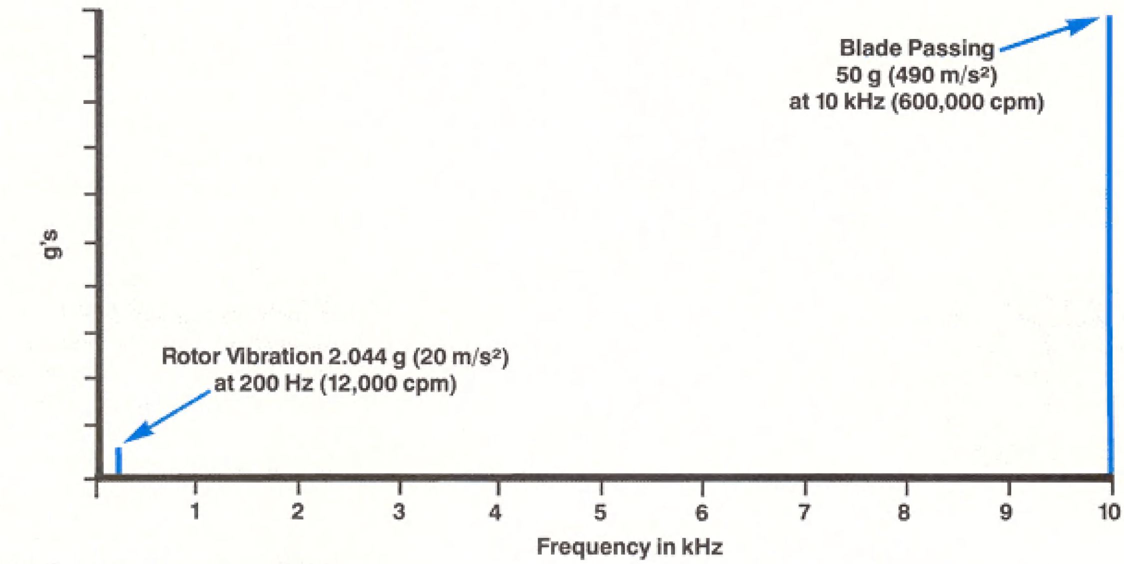


Figure 1

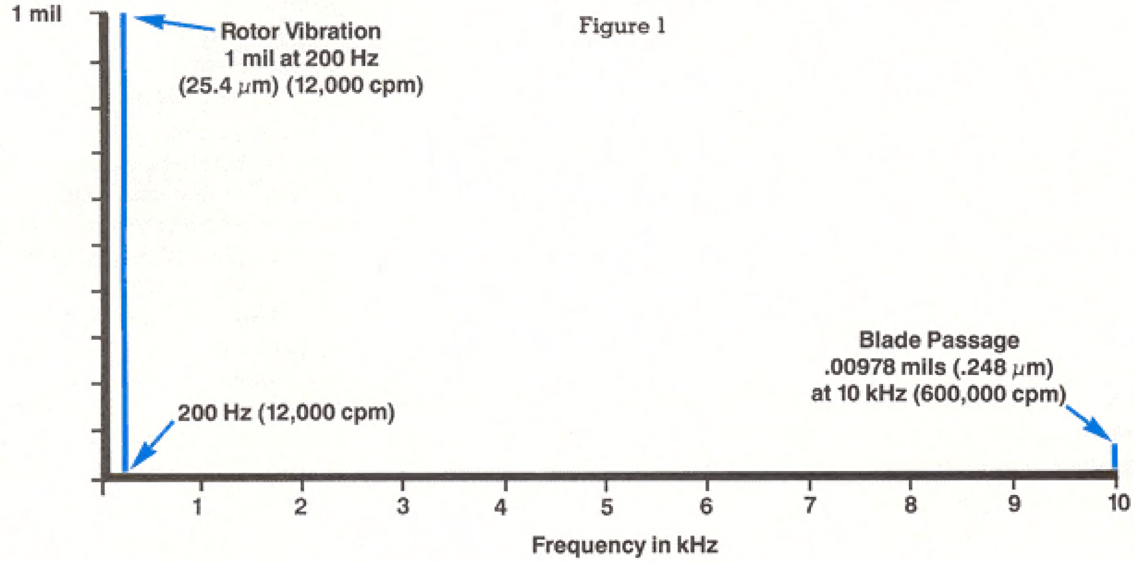


Figure 2

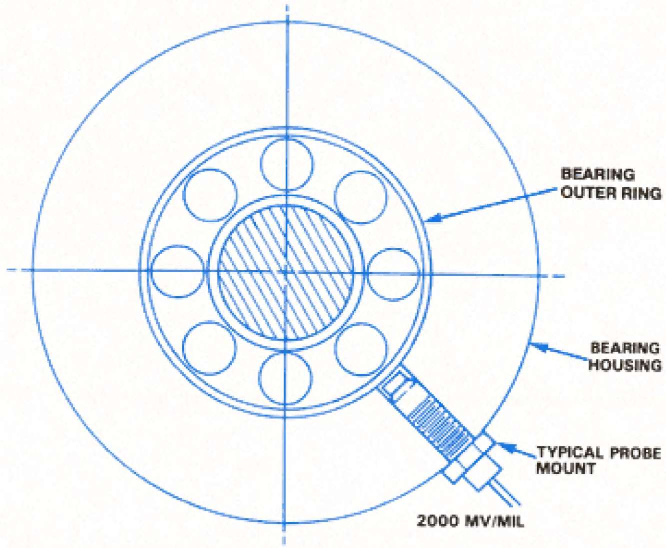
As was stated previously, blade passage vibration acceleration amplitudes are typically 10 to 100 times higher than those from rotor vibration sources. Reliably extracting the small rotor vibration signals from the high amplitude blade vibration signals is not a simple task. The monitoring system must have a wide dynamic range to prevent saturation by blade passing frequency vibration. Both signal integration and special filtering are needed. The monitoring system becomes very complex. because of this complexity, the system is more susceptible to false alarms and/or missed detection of a real machine malfunction.

To achieve reliable machine information, a vibration monitoring system must be simple. Direct measurement of rotor vibration can play an important role in achieving this reliability. It allows the monitor to be simple and thus more reliable.

Direct measurements

Bently Nevada offers shaft and bearing outer ring observing displacement transducers and vibration monitoring systems for aeroderivative gas turbines. These systems provide more complete machinery vibration information than seismic transducer based monitoring systems. These monitoring systems do not need the wide dynamic range, special filtering, and electronic integration required by seismic systems. As a result, they are simpler and more reliable.

Since these are direct measurements, they do not depend on a transfer ratio which is seldom constant. Since displacement is being measured, a wide dynamic range is not required to prevent saturation by blade passing frequency vibration. This is because blade passing►



TYPICAL REBAM® PROBE MOUNT

The REBAM® transducer provides a high sensitivity, low noise, direct measurement of very small deflections of the outer ring of a rolling element bearing. This information is used to detect the following:

1. Rotor related problems.
2. Conditions that can lead to premature bearing failure.
3. Bearing failure.

Figure 3

frequency vibration, even though it has high acceleration amplitudes, has low displacement amplitudes.

As an example, 50 g's (490 m/s²) acceleration at 10 kHz (600,000 cpm) is only 4.89 microinches (0.124 micrometres) displacement.

Figures 1 and 2 compare relative acceleration and displacement levels of a typical rotor vibration signal 1 mil (25 μm) at 200 Hz and typical blade passing signal 50 g's (490 m/s²) at 10 kHz. Comparison of this data shows that, when measuring acceleration, the level of the blade passing frequency signal is approximately 25 times greater than the acceleration level of the rotor vibration signal.

Similarly, when measured in displacement, the rotor vibration signal is approximately 100 times greater than the blade passing signal. Therefore, when measuring rotor vibration, a proximity probe which measures displacement is the preferred measuring device.

In addition to the advantage of being a direct measurement, the presence of high frequency, high acceleration level blade passing frequency vibration has very little effect on a proximity probe's output.

These systems are based on proximity probes specially developed for this application. The probe tip and body will operate at temperatures up to 500°F (260°C). Two types of probe cables are available. One is a flexible cable that will operate at temperatures up to 482°F (250°C). This will withstand the temperatures normally encountered exiting the compressor portion of the turbine. The other is a semi rigid cable that will operate at temperatures up to 1800°F (982°C). This will withstand the temperatures often encountered when exiting the turbine through the hot gas path. These transducers overcome most of the temperature problems that are encountered with installation of proximity probes in aeroderivative gas turbines.

Rotor support in aeroderivative gas turbines is provided by rolling element bearings. Many utilize squeeze film dampers. Standard sensitivity proximity probes are often very effective in measuring shaft vibration in these cases. A proximity probe can observe either the shaft near the bearing or the outer ring of the bearing. The motion of the outer ring of a squeeze film damped bearing is essentially the motion of the shaft because virtually all of the shaft motion appears across the damper.

Direct shaft relative measurements with standard sensitivity proximity probes are also useful with rigidly mounted bearings, especially when measurements are made several shaft diameters away from the bearings.

In the case of rigidly mounted rolling element bearings, a monitoring system is available that uses a special high sensitivity proximity probe transducer system called REBAM® (Rolling Element Bearing Activity Monitor). The REBAM® proximity probe directly measures the small deflections in the outer ring of a rolling element bearing (Figure 3). In addition to providing rotor related information, REBAM® is useful in detecting bearing failure.

Proximity probes can also be used to provide a Keyphasor® (once-per-revolution) signal. This is very useful in balancing and rotor diagnostics.

Summary

Seismic transducers have limitations. One must understand and consider these limitations when specifying seismic transducers exclusively for monitoring aeroderivative gas turbines. Direct reading shaft or REBAM® probes overcome many of these limitations and can provide superior performance. Bently Nevada Corporation is ready to help you engineer and install the proper combination of vibration transducer to provide a reliable and effective monitoring system for your aeroderivative gas turbine.